

WHAT IS CLAIMED IS:

1. In a power amplifier system in which a digital input transmission signal is adaptively predistorted to compensate for non-linearities in an amplification process based on a difference between a desired and an observed amplifier output, a method of generating a digital error signal that accurately represents said difference, comprising:

adaptively processing the digital input transmission signal at least partially in response to a digital error signal to generate a modified signal that complements non-linearities resulting from the amplification process;

converting the first modified signal to analog form to produce an analog modified signal, which is related to a signal that is amplified by the amplification process;

down-converting a radio frequency (RF) signal that represents an actual output of the amplifier system to generate a feedback signal;

processing the digital input transmission signal to provide a desired output signal;

converting the desired output signal to analog form to produce an analog delayed signal;

taking a difference between the feedback signal and the desired output signal to generate an analog error signal;

scaling the analog error signal to produce a scaled error signal that substantially corresponds to a range of an analog-to-digital converter; and

using the analog-to-digital converter to convert the scaled error signal to digital form to produce the digital error signal.

2. The method as in Claim 1, wherein processing the digital input transmission signal to generate the desired signal further comprises phase rotating the desired signal relative to the input transmission signal.

3. The method as in Claim 1, wherein processing the digital input transmission signal to generate the desired signal further comprises amplitude scaling the desired signal relative to the input transmission signal.

4. The method as in Claim 1, wherein processing the digital input transmission signal to generate the desired signal further comprises delaying the desired

signal relative to the input transmission signal such that the desired signal is substantially time aligned with the feedback signal.

5           5.       The method as in Claim 2, wherein adaptively processing the digital input transmission signal further comprises amplitude scaling the input transmission signal.

6.       The method as in Claim 1, wherein processing the digital input transmission signal to provide a desired output signal further comprises adaptively adjusting the processing to reduce a magnitude of the analog error signal.

10          7.       A method of transmitting a radio frequency (RF) power signal, the method comprising:

          receiving an input signal;

          predistorting the input signal, where the predistortion compensates for at least part of an intrinsic distortion of a power amplifier;

15           up-converting the predistorted input signal such that a carrier wave is modulated with the predistorted input signal;

          amplifying the modulated carrier wave with the power amplifier;

          sampling an output of the power amplifier;

          down-converting the sample of the output of the power amplifier to an intermediate frequency;

20           delaying the input signal such that a content of the input signal is substantially time aligned with the content of the down-converted sample of the output of the power amplifier;

25           combining the delayed input signal with the down-converted sample such that an amplitude of the combined signal is less than an amplitude of the down-converted sample;

          converting the combined signal from analog to digital; and

          receiving the digital combined signal and revising the predistorting of the input signal in response to the digital combined signal such as to reduce a distortion in the output of the power amplifier.

8. The method as defined in Claim 7, wherein the combining of the delayed input signal with the down-converted sample substantially eliminates a main signal component of the down-converted sample from the combined signal.

9. A method of generating an error signal that can be used to reduce distortion in a radio frequency (RF) output signal of an RF transmitter, the method comprising:

receiving a sample of the output signal of the transmitter;

down-converting the sample of the output signal from an RF signal to a down-converted signal;

receiving an input signal of the transmitter, where the input signal is digital;

delaying the input signal to produce a delayed input signal to approximately time align an analog delayed input signal with the down-converted signal;

converting, from digital to analog, the delayed input signal to the analog delayed input signal;

combining the down-converted signal with the analog delayed input signal to produce a modified down-converted signal such that an amplitude of the modified down-converted signal is reduced relative to an amplitude of the down-converted signal; and

converting the modified down-converted signal, from analog to digital, to produce the error signal.

10. The method as defined in Claim 9, wherein down-converting the sample of the output signal from the RF signal to the down-converted signal comprises down-converting the sample to complex baseband.

11. The method as defined in Claim 9, wherein down-converting the sample of the output signal from the RF signal to the down-converted signal comprises down-converting the sample to an Intermediate Frequency (IF).

12. The method as defined in Claim 9, wherein combining the down-converted signal with the analog delayed input signal further comprises subtracting the analog delayed input signal from the down-converted signal.

13. The method as defined in Claim 9, wherein delaying the input signal further comprises adaptively adjusting the delay in response to the error signal to further reduce the amplitude of the modified down-converted signal.

14. The method as defined in Claim 9, further comprising phase rotating the delayed input signal relative to the input signal to further reduce the amplitude of the modified down-converted signal.

15. The method as defined in Claim 14, further comprising adaptively phase rotating the delayed input signal relative to the input signal in response to the error signal to further reduce the amplitude of the modified down-converted signal.

16. The method as defined in Claim 9, further comprising scaling the delayed input signal relative to the down-converted signal such that the amplitude of the modified down-converted signal is further reduced.

17. The method as defined in Claim 16, further comprising adaptively scaling the delayed input signal relative to the down-converted signal in response to the error signal such that the amplitude of the modified down-converted signal is further reduced.

18. The method as defined in Claim 9, further comprising adaptively scaling an amplitude of the modified down-converted signal in response to the error signal to conform the amplitude of the modified down-converted signal to an input range of an analog-to-digital converter.

19. A method of generating an error signal that can be used to reduce distortion in a radio frequency (RF) output signal of an RF transmitter, the method comprising:

receiving a sample of the output signal of the transmitter;

down-converting the sample of the output signal from an RF signal to a down-converted signal;

receiving an input signal of the transmitter, where the input signal is digital;

converting, from digital to analog, the input signal to an analog input signal;

delaying the analog input signal to approximately time align the delayed analog input signal with the down-converted signal;

combining the down-converted signal with the delayed analog input signal to produce a modified down-converted signal such that an amplitude of the modified down-converted signal is reduced relative to an amplitude of the down-converted signal; and

converting the modified down-converted signal, from analog to digital, to produce the error signal.

20. A method of responsively filtering a first component from a first signal to efficiently utilize an input range of an analog-to-digital converter used to detect and measure a second component of the first signal, the method comprising:

receiving the first signal;

receiving a second signal, where the second signal is related to the first component of the first signal;

delaying the second signal to align the second signal with the first component of the first signal;

subtracting the second signal from the first signal to generate an error signal; and

applying the error signal to the analog-to-digital converter.

21. The method as defined in Claim 20, further comprising adjusting a relative amplitude of the error signal versus an input range of the analog-to-digital converter such that the error signal approximately conforms to the input range.

22. The method as defined in Claim 20, further comprising adjusting a relative amplitude of the first signal versus the second signal to decrease an amplitude of the error signal.

23. The method as defined in Claim 20, further comprising adjusting a phase of the first signal versus the second signal to decrease an amplitude of the error signal.

24. The method as defined in Claim 20, wherein delaying the second signal further comprises adjusting the delay of the second signal to maintain alignment of the second signal with the first component of the first signal.

25. A circuit that responsively filters a first component from a first signal to efficiently utilize an input range of an analog-to-digital converter used to detect and measure a second component of the first signal, the circuit comprising:

means for receiving the first signal;

5 means for receiving a second signal, where the second signal is related to the first component of the first signal;

means for delaying the second signal to align the second signal with the first component of the first signal;

10 means for subtracting the second signal from the first signal to generate an error signal; and

means for applying the error signal to the analog-to-digital converter.

26. A radio frequency (RF) transmitter with adaptive predistortion comprising:

15 a predistortion circuit that predistorts an input signal to a predistorted input signal in response to maintained coefficients in a predistortion kernel, where the predistortion is substantially complementary to an intrinsic distortion in an RF power amplifier;

an RF up-converter, which produces a modulated a carrier wave from the predistorted input signal;

20 the RF power amplifier, which amplifies the modulated carrier wave;

a coupler, which provides a sample of the amplified modulated carrier;

an RF down-converter, which converts the sample of the amplified modulated carrier wave to a down-converted signal;

25 a digital filter adapted to delay the input signal to produce a delayed input signal;

a second digital-to-analog converter that converts the delayed input signal to an analog delayed input signal;

30 a summing node adapted to combine the analog delayed input signal with the down-converted signal to generate a summed output such that the analog delayed input signal and the down-converted signal at least partially destructively interfere;

an analog-to-digital converter that converts the summed output to a digital summed output; and

an adaptive control processing and compensation estimator circuit that monitors the digital summed output and provides updates to the predistortion circuit such that the predistortion of the input signal remains substantially complementary to the intrinsic distortion of the RF power amplifier.

27. The RF transmitter as defined in Claim 26, wherein the adaptive control processing and compensation estimator circuit further updates the digital filter at least partially in response to the digital summed output, where the updates vary the delay of the digital filter to increase the destructive interference at the summing node.

28. The RF transmitter as defined in Claim 26, wherein the digital filter further phase rotates and amplitude scales the delayed input signal to increase the destructive interference at the summing node.

29. The RF transmitter as defined in Claim 28, wherein the adaptive control processing and compensation estimator circuit responds to the digital summed output to further update the digital filter to vary the delay, to vary the phase rotation, and to vary the amplitude scaling of the delayed input signal to increase the destructive interference at the summing node.

30. A circuit that generates an error signal that can be used by a predistortion circuit to reduce a distortion in a radio frequency (RF) output signal of an RF transmitter, the circuit comprising:

a digital filter adapted to delay and phase rotate an input signal of the RF transmitter along a side path, where the delay is configurable to approximately coincide with a first delay in time of a forward transmitting path and a return path with a second delay in time of the side path;

a first conversion circuit adapted to convert an output of the digital filter to a delayed version of the input signal, where the delayed version of the input signal is analog;

an RF down-converter adapted to convert a sample of the RF output signal to a down-converted signal;

a differencing circuit adapted to combine the output of the conversion circuit with the down-converted signal to produce a difference signal such that a main signal component of the down-converted signal is reduced in the difference signal by subtraction of the delayed version of the input signal from the down-converted signal; and

a second conversion circuit adapted to convert the difference signal to a digital form.

31. The circuit that is defined in Claim 30, wherein the differencing circuit is a summing circuit, and where a main signal component of the delayed version of the input signal is substantially out of phase with respect to the main signal component of the down-converted signal.

32. A circuit that filters a first component from a first signal to efficiently utilize an input range of an analog-to-digital converter used to detect and measure a second component of the first signal, the circuit comprising:

a delay circuit adapted to delay a second signal to a delayed second signal such that an analog form of the delayed second signal aligns with the first component of the first signal;

a conversion circuit adapted to convert the delayed second signal from digital to analog form; and

a comparison circuit adapted to combine the analog form of the delayed second signal with the first signal such that the presence of the first component is diminished in an output of the comparison circuit.